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ABSTRACT

Recognizing that an important key to success of developing solar technologies is the availability of skilled labor to produce, install, and maintain it, the Talcott Mountain Science Center in Avon, Connecticut created a training program for vocational-technical and high school staff. The program's goal was to develop curriculum materials that would enable these teachers to add solar energy technical training to their vocational curricula. These materials were developed in the first two phases of the program. In this final phase, 4 objectives were met: (1) an instructional resource guide to be used as a curriculum infusion unit by vocational education teachers in the area of solar energy was distributed; (2) the awareness of vocational education teachers to existing curriculum materials was increased; (3) a series of solar energy workshops throughout the state, attracting 25 to 30 participants each, was conducted; and (4) participants of the Model Solar Energy Training Programs I and II were identified and selected to help conduct workshops in their regions. In addition to these activities for classroom teachers, an initial workshop for supervisors and administrators to review the material and activities developed by Talcott Mountain Science Center was held. (The curriculum guide, with lesson plans for suggested activities in the area of solar installations, is included in this document.) (KC)

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1982

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MODEL SOLAR ENERGY TRAINING PROGRAM III

FINAL REPORT

PREPARED BY:

TALCOTT MOUNTAIN SCIENCE CENTER FOR STUDENT INVOLVEMENT, INC.

MONTEVIDEO ROAD, AVON, CONNECTICUT

PREPARED FOR:

CONNECTICUT STATE DEPARTMENT OF EDUCATION

DIVISION OF VOCATIONAL EDUCATION

BUREAU OF VOCATIONAL PROGRAM PLANNING & DEVELOPMENT

HARTFORD, CONNECTICUT 06115

PROJECT DIRECTOR: DR. DONALD P. LA SALLE, DIRECTOR
TALCOTT MOUNTAIN SCIENCE CENTER

STAFF: GEORGE C. ATAMIAN
ROBERT S. AMREIN
JONATHAN CRAIG

This project was supported by funds available to Connecticut through the Vocational Education Act of 1976, Public Law 94-482.

All opinions expressed reflect the views of the authors and are not necessarily those of the State Department of Education.

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TABLE OF CONTENTS

Acknowledgements i

Preface ii

Abstract iii

Introduction

The Problem 1

Rationale 2

Goals and Objectives 2

Summary

Findings 4

Recommendation 4

Conclusion 5

Project Design 6

Appendices

ACKNOWLEDGEMENTS

We would like to thank those individuals of the Bureau of Vocational Program Planning and Development (BVPPD) for funding a truly important project for the third year. The guidelines, intent, and operation of this project, and others funded through the same program, have been discussed at awareness meetings conducted by the Bureau. At these sessions, participants were encouraged to ask questions in an atmosphere of free exchange which benefited all present.

We are also grateful for the on-site visits to the Project made by Bureau personnel. The opportunities to display what we were about, and to discuss our approaches and techniques was of great benefit to us.

In particular, we acknowledge the help and guidance of Dr. Elizabeth Schmitt, Chief of BVPPD, and Dr. Valerie Pichanik, Consultant, BVPPD. We would also like to thank Mr. Edward Butler, Sunrise Solar, Mr. Philip Fine, Vice President of Energy Research Group, and Mr. Edward Morris, H. C. Wilcox Regional Technical School, for advising us on this project. We would also like to thank Mr. Edward Shia, Bureau of Vocational Services, whose recommendation to modify the number of activities made this project feasible. Their cooperation in reviewing the workshop materials and helping to keep the workshop personnel up to date with new solar technology has greatly enhanced this project.

PREFACE

> "One institutional barrier (to effective use of solar energy systems) is lack of skills in installing and maintaining solar systems. Indeed, recent experience suggests that poor installation is a far greater problem than reliability of the solar equipment itself."[1]

Thus, the report of the Energy Project at the Harvard University Business School hit on the growing problem of modern society and an important challenge to vocational education: Will we have the technical skills to succeed to move toward our goal of energy independence using new energy technologies?

Recognizing that an important key to success of developing solar technologies would be the availability of skilled labor to produce, install and maintain it, the Talcott Mountain Science Center in Avon created a unique training program for vocational-technical and high school staff. The program's goal was to develop curriculum materials which would enable vocational-technical and high school teachers to add solar energy technical training to their vocational curricula.

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[1] 1979-1981 Vocational Education Improvement Projects prepared by the Connecticut State Department of Education.

ABSTRACT

TITLE OF PROJECT: A Model Solar Energy Training Program for Vocational Education Teachers - III - The Dissemination Model

PROJECT DIRECTOR: Dr. Donald P. La Salle

APPLICANT ORGANIZATION: Talcott Mountain Science Center of Student Involvement
Montevideo Road
Avon, Connecticut 06001

TOTAL REQUESTED FUNDS: $5,000.00

BEGINNING DATE: September 1, 1981

ENDING DATE: June 30, 1982

OBJECTIVES:

1. To distribute an instructional resource guide to be used as a curriculum infusion unit by vocational education teachers in the area of solar energy.
2. To increase the awareness of vocational education teachers to existing curriculum materials developed for use with their classes.
3. To conduct a series of solar energy workshops distributed geographically within the state to attract 25-30 participants per workshop.
4. To identify participants of the Model Solar Energy Training Programs I and II as resource personnel by selecting participants to help conduct workshops in their regions.

It is important that the experiences, activities, and curriculum materials identified as specific and useful for needs of vocational education teachers by the participants of the Model Solar Energy Training Program I and II be disseminated to teachers unable to attend these programs.

This project will focus not only on the classroom teacher but on the supervisors and administrators whose support is so valuable to the classroom teacher. An initial workshop for supervisors and administrators to review the material and activities developed by Talcott Mountain Science

Center and the participants of the Model Solar Energy Training Programs I and II will be held in September, 1981. This session will focus on the needs for and types of activities and materials required for the teaching of energy conservation and solar heating in the vocational and industrial arts areas. Participants will have the opportunity to dialogue with people working in the fields of energy conservation and systems installation thereby hearing descriptions of the kind of student acquired skills needed for viability in the market place.

In addition, participants in this initial workshop will have the opportunity to see the type of materials developed and how the Center proposes to get this information to their teachers.

The second part of the Dissemination Program will consist of approximately six half-day workshops held at the various regional locations in Connecticut. These gatherings will be designed for the teacher and divided into three modules: an overview to the energy problem itself; hands-on experiences with activities developed during the Model Solar Energy Training Programs; and exposure to additional curriculum materials available to them.

It is felt that this approach with both an administrator and teacher workshop would best serve the purpose to disseminate the material developed. This would give the administrators an opportunity to discuss the need for such a curriculum and to see how such materials could be infused into the existing curriculum with maximum effect and minimum disruption. The leadership workshop would also help administrators in selecting teachers who would best benefit from the workshops.

INTRODUCTION

THE PROBLEM

The last three generations of Americans have been taught to consume energy without regard for the associated problems of cost, supply, environmental consequences and depletion of reserves. Now, as the era of "cheap oil" rapidly comes to a close, nations are scrambling for what remains. This behavior has already driven the cost of oil, on the spot market, to more than $40 for each barrel of forty-four gallons of crude oil. Concurrently, the value of the dollar is proportionately lowered. Clearly, we must act soon to reduce our dependence on foreign oil and generate a philosophy which makes conservation of energy resources a reality. At the same time, we will develop alternate sources of energy which are dependent on the renewable and steady influx of solar radiation.

By taking bold and necessary steps now, we can produce enough solar technologies to supply up to twenty percent of our energy needs over the next generation. At the same time, conservation can save us thirty to forty percent in energy with virtually no major changes in our standard of living. Additionally, the energy needed to produce solar collectors can be derived from coal mined in America while the fabrication of the panels themselves can be accomplished in Connecticut and other New England states.

Of course, these are not magical solutions. Considerably more energy must be expended to manufacture and install the solar energy devices than will be gathered by the devices themselves. This is also true for the production of gasoline or the manufacture of Uranium fuel pellets used in

nuclear reactors. However, we can minimize our dependence on foreign oil, expensive and environmentally harmful synfuels and nuclear sources by maximizing our usage of solar alternatives.

RATIONALE

Undoubtedly, solar technology will improve greatly with the passage of time and increasing expenditures for research and development in that field by private industry. Still, at this time there are several adequate solar devices on the market ready to be installed on both existing homes and on new construction. What is sadly lacking are sufficient numbers of individuals skilled in sizing and applying these solar systems. We feel it is imperative that vocational teachers be provided with the tools and training to insure that knowledge of proper techniques reaches the vocational student in time to meet the need which becomes greater daily.

The dissemination workshop project will serve to expand the number of vocational educators able to infuse energy curriculum into their existing courses.

The commitment of the State of Connecticut to the commercialization of solar systems is clear as indicated by its program which provides 6% loans for approved projects. At the same time, the federal government is allowing "double-dipping" for the above program and is encouraging the installation of solar systems and other active and passive solar projects for the citizen.

GOALS AND OBJECTIVES

The significance of the present energy crisis and the portent of even more dire circumstances in the near future almost mandates the need for effective energy programs in all schools.

The immediate goal of providing cost-effective alternative technologies is becoming more salient every day. It is imperative that vocational teachers be provided with proper tools and training to ensure that this information reaches the vocational student in time to meet the impending demand for alternative sources of energy and the skilled technicians needed to install such facilities and equipment.

The Dissemination Project will put in the hands of teachers materials that will serve as a stepping stone for continued curriculum development in the vocational schools. The goals of this project will augment and supplement the long range goals of the state vocational programs and build upon the "new foundations" laid by such courses already underway.

SUMMARY

1. Findings: At this time last year, we were happy to report over half of the teachers who had participated in the original Model Solar Energy Training Program (M.S.E.T.P.) I and II were teaching courses on energy including adult education and college courses. As we traveled to schools to conduct workshops, several former M.S.E.T.P. teachers asked to bring their students to the workshops to learn about the latest developments in the energy fields.

An analysis of the evaluation instrument used during the year (see Appendix A) indicates that 80% of the participants that responded found the workshops not only useful but recommended them for other teachers.

In the fall, it was anticipated that each workshop would have approximately 25 participants allowing us to reach 150 teachers. In looking at the attendance lists for each workshop (Appendix B) it can be noted that, except for the first workshop, the majority of the participants were from the school where the workshops were being held. This number does not reflect the presence of actual Voc-Ed students that attended with former participants.

2. Recommendation: The only recommendation that we have at this time is for future dissemination projects to try to have their program in conjunction with regular scheduled in-service programs at each Voc-Ed school. For whatever reason, distance between schools, after school commitments, or different schedules at different schools, the majority of the participants were from the local school. The purpose of any dissemination project is to reach as many people as possible. It has been our experience that the highly motivated teacher will make the extra effort to participate in programs they think might benefit them.

3. Conclusion: It is evident that teachers need the knowledge and skills to become effective promoters of the alternative energy technologies in the classroom.

Although many teachers have begun to incorporate these technologies into their existing programs, the majority of teachers do not have available to them the materials or resources to institute these ideas. Through the M.S.E.T.P. series we used teachers to assess a need and to develop an approach to the dissemination and infusion of the solar technologies into existing vocational programs. As a result, we have reached a large number of teachers and have aided them in their efforts to bring the solar technologies into their classrooms. We feel that all teachers at all levels can make a significant contribution towards the solution of our energy crisis. We at Talcott Mountain Science Center will continue to promote this idea through our ongoing and future programs including the following proposals:

a. To offer workshops on new technologies in energy related fields.

b. To revise and develop new curriculum materials for use in the classroom for all grade levels.

c. To make the facilities and resources of the Science Center available at a reduced rate, to the participants trained in the M.S.E.T.P. programs I and II. Fifty students from Hartford Public High School under the direction of Art Skerker, a participant in M.S.E.T.P. II took advantage of this opportunity with a tour of the solar facilities and participation in two activities. One taught by Mr. Skerker using the Center's equipment while Jonathan Craig of TMSC worked with the second activity. This made a very full afternoon for these students.

d. To maintain all participants on the Center's mailing list for information on up coming events and developments.

PROJECT DESIGN

During the summer of 1981, George C. Atamian, Robert S. Amrein, and Jonathan Craig of the Talcott Mountain Science Center met with former participants of M.S.E.T.P. I and II and several high school teachers to review the curriculum materials selected for the dissemination project. A copy of the final activities was produced in booklet form for use in this project (see Appendix C).

The project design was based on recommendations drawn from the final report of the Model Solar Energy Training II. The project was divided into two parts: the first being an initial contact with the supervisors and administrators to allow them to review and learn about the program first hand; the second part consisted of instructional workshops for classroom teachers.

Through the help of Dr. Valerie Pichanick of the Bureau of Vocational Program Planning and Development, Robert S. Amrein, Talcott Mountain Science Center, was invited to address the fall Vocational-Technical school directors' meeting on September 28 in Bridgeport, Connecticut. At this time, each director was given a copy of the curriculum guide and a brief outline of the Dissemination Project and its goals. It was expected that the directors would review the materials and distribute to teachers with the need to know.

At the same time, the directors were informed of the planned workshops and to expect to hear from the Center about the exact location and times for each regional session. The sites for the workshops were based on

locations that had not been reached by Talcott Mountain Science Center in the past few years when the energy workshops were conducted for high school teachers. The sites selected were Bridgeport, Groton, Danbury, Meriden, Willimantic, and Torrington. Permission was obtained from Commissioner Tedesco to use space in schools in those towns (see Appendix D). Flyers announcing the sessions (see Appendix E) were mailed to every vocational-technical school and high school in the state of Connecticut. This mailing was made by mid-December with the first workshop scheduled for January 12th. In addition to sending the flyers to schools, they were mailed to Mr. Edward Shia, from the Trade and Industrial Education Division of the Bureau of Vocational Services; Mr. Robert Kelly, from the Community and Adult Education; and Mr. Fred Edwards, from the Bureau of Youth, Employment and Training Services.

The structure of the six regional workshops was tripartite:

1. slide overview of the current state of the energy problem and possible solutions;
2. a hands-on investigation of the curriculum developed by the participants of M.S.E.T.P. I and II;
3. a chance to interact with an expert in the field of energy curriculum and to look at materials being developed nationally.

To implement the program, Robert S. Amrein and Jonathan Craig of the Talcott Mountain Science Center were selected to conduct the sessions. Robert S. Amrein is an Assistant Director of the Talcott Mountain Science Center and was intimately involved with M.S.E.T.P. I and II. In addition, Mr. Amrein was the regional resource agent for the Solar Energy Project, a 7-12 grade curriculum project funded by Northeast Solar Energy Center. In

this capacity, he has conducted well over fifty solar energy workshops throughout Connecticut and New England. He also co-authored "Energy Watch," a 7-12 grade curriculum developed for the State of Connecticut.

Secondly, Mr. Jonathan Craig of TMSC was selected because of his extensive background in energy. Mr. Craig was the area coordinator for the Adult Education Project funded by the Northeast Solar Energy Center, one of the authors of "Energy Watch," a 7-12 grade curriculum developed for the State of Connecticut, and is concurrently on the Board of Directors of the Northern Connecticut Solar Association. His experience in teaching as well as his knowledge of energy curriculum added much to this project.

The format of the Curriculum Guide and Teacher Training Workshops was based upon the wide ranging background of the teachers in the previous programs. The activities were sequentially arranged from simple to more complex in order to be infused into many levels of a school curriculum. Each activity contains general background information, ideas for displays, a working hands-on project, and specific information for advanced classes.

A series of six workshops were scheduled after school hours (3:30-6 PM) for the regional Voc-Ed schools (see Appendix E). Each meeting was opened with introductions of participants to determine specific areas of interest. This was followed by a slide presentation to present current energy problems and new technologies. Questions were entertained through the presentation.

Participants were asked to assemble and test hot air collectors (see Appendix C, page 14), and involved in the finer points of orienting a compass and using a sun locator (see the solar site activity).

The Center also provided a series of handouts from state and federal sources and introduced the participants to curriculum guides, current journals and publications in the energy fields. As stated before, the main goal of this project was to put into the hands of teachers energy related materials that will serve as a stepping stone for continued curriculum development in vocational and high schools of Connecticut. Beyond this year, each participant was encouraged to continue using the staff of Talcott Mountain Science Center as an energy resource and informed that the Center would be offering follow-up sessions next year.

DISSEMINATION

The existence and purpose of the Model Solar Energy Training Program was announced and disseminated via the following vehicles:

- Newspaper articles
- Mailing to all Junior High and Secondary Schools in Connecticut
- Presentation to Northern Connecticut Solar Association.

APPENDIX A

TALCOTT MOUNTAIN SCIENCE CENTER

WORKSHOP/SEMINAR EVALUATION

Workshop Name: _____

Date: _____

1. Were the objectives of the workshop clear to you? YES____ NO ____

   Comments: _____

   _____

   _____

2. How would you rate the quality of the presentation?

   Excellent _____ Good _____ Fair _____ Poor _____

3. Rate the workshop content on the following scale:

	1	2	3	4	5	
Helpful						Not Helpful
Practical						Not Practical
Clear						Vague
Important						Not Important
Recommend						Not Recommended

4. What was the strongest feature of the workshop? _____

   _____

   _____

5. What was the weakest feature of the workshop? _____

   _____

   _____

6. COMMENTS: _____

   _____

   _____

   _____

1981

PARTICIPANTS

NAME	SCHOOL	TOWN
Bullard-Havens Regional, Bridgeport		
Balouskus, Rich	Ansonia High School	Ansonia
Bertone, Ignatius	Bassick High School	Bridgeport
Bransfield, Liannd M.	Platt RVTS	Milford
Caruso, Fred A.	Emmett O'Brien Tech.	Ansonia
Ford, Robert Jr.	Fairfield Prep.	Fairfield
Kelman, Gary	Jim Wright Tech.	Stamford
Moulton, Norman R.	Amity Regional	Orange
Pitman, Patricia	Sacred Heart Academy	Stamford
Webb, Richard R.	Emmett O'Brien RVTS	Ansonia
Southeastern Regional, Groton		
Bunnell, Paul	Old Saybrook Jr. H.S.	Old Saybrook
Collins, Henry B.	Southeastern Tech.	Groton
Contolini, Nancy	Old Saybrook Jr. H.S.	Old Saybrook
Cornett, L. A.	Southeastern RVTS	Groton
Edwards, Fred	SDE - Bureau of Youth Employment	Hartford
Fernandes, Richard D.	Southeastern RVTS	Groton
Fillion, Ray	E. T. Grasso, Southeastern RVTS	Groton
Furr, Ronald L.	Southeastern RVTS	Groton
Gilardi, Maureen	Southeastern RVTS	Groton
Mierzejewski, Leonard	Old Saybrook Jr. H.S.	Old Saybrook
Osga, Marty	Southeastern RVTS	Groton
Panish, Peter	Southeastern RVTS	Groton
Wilkins, Marilyn	Old Saybrook Jr. H.S.	Old Saybrook
Samuels, Jane	Williams School	New London

NAME	SCHOOL	TOWN
Henry Abbott Regional, Danbury		
Boccuzzi, John S.	Stamford H.S.	Stamford
Fermeglia, Al	Henry Abbott Tech.	Danbury
Hunt, Thomas J.	Henry Abbott Tech.	Danbury
Setaro, J. Arthur	Henry Abbott Tech.	Danbury
Tallent, Wm. C.	Henry Abbott Tech.	Danbury
H. C. Wilcox Regional, Meriden		
Bucher, Edward D.	Emmett O'Brien RVTS	Ansonia
Jensen, Rick	Suffield High School	Suffield
Latina, Anthony E.	Wethersfield H.S.	Wethersfield
McGirr, Donald W.	H. C. Wilcox RVTS	Meriden
Mongillo, Ed	H. C. Wilcox RVTS	Meriden
Tsinesyrt, Robert	Berlin High School	Berlin
Rich, Daniel	Board of Education Office	Glastonbury
Riedinger, Dale A.	J. F. Kennedy Jr. H.S.	Southington
Ruggeri, Gary	Northwest Catholic H.S.	West Hartford
Siciliano, Tom	Rocky Hill H.S.	Rocky Hill
Slicer, Madeline	Amity Jr. High	Bethany
Walczak, Joseph P.	H. C. Wilcox RVTS	Meriden
Willmott, Norman E.	H. C. Wilcox RVTS	Meriden
Wilson, Gregory	Amity Jr. H.S.	Bethany
Windham Regional, Willimantic		
Abissi, Charlene	East Windsor High	East Windsor
Bergeron, Ronald	Brooklyn School	Brooklyn
Bloom, LeRoy B.	E. O. Smith H.S.	Storrs
Carey, Jane	Windham H.S.	Willimantic
Dorko, John	East Windsor High	East Windsor

NAME	SCHOOL	TOWN
Forrest, Larry	L. P. Wilson Jr. H.S.	Windsor
Gag, Larry	Parish Hill H.S.	
Moshier, Wayne R.	RHAM High School	Hebron
Lawnsby, Rosemary	Windham Tech.	Willimantic
Osyf, Myron	L. P. Wilson Jr. High	Windsor
Palmer, Tom	Windham Tech.	Willimantic
Paquette, C.	Windham Tech	Willimantic
Pernaselli, M.	Windham Tech	Willimantic
Post, Kenneth	Brooklyn School	Brooklyn
Germain, Mary Anne	Windham High	Willimantic
Shackleton, Richard	Windham Tech	Willimantic

Oliver Wolcott Regional, Torrington

DeVito, Anthony	Oliver Wolcott	Torrington
DiFronzo, Italo	Oliver Wolcott	Torrington
Evans, Brian	Oliver Wolcott	Torrington
Farmer, Eloise	Torrington H.S.	Torrington
Fuhrman, Wm. A.	Oliver Wolcott	Torrington
Langenheim, Harry A., Jr.	Oliver Wolcott	Torrington
Mudano, Diane	Oliver Wolcott	Torrington
Nicholas, George	Canton	Canton
Olexa, John	Oliver Wolcott	Torrington
Ruth, George	Oliver Wolcott	Torrington
Taylor, William E.	Sedgqick Middle School	West Hartford
Wilee, Rheta	Oliver Wolcott	Torrington
Coyle, Kevin W.	Oliver Wolcott	Torrington

APPENDIX B

Participant's Name and School

1.	Richard A. Jensen	Suffield High School, Suffield, CT
2.	Frederick Clark	Suffield High School, Suffield, CT
3.	William Leahy	Haddam/Killingworth High School, Haddam, CT
4.	Charles Zierzow	Regional # 7, Winsted, CT
5.	Thomas Langlais	Howell Cheney RVTS, Manchester, CT
6.	John P. Kleis	Howell Cheney RVTS, Manchester, CT
7.	Fran Romano	Somers High School, Somers, CT
8.	Wilfred Reil	Wamogo High School, Litchfield, CT
9.	Douglas A. Moody	American School for the Deaf, W. Hartford, CT
10.	Perry De Angelis	Simsbury High Schoo, Simsbury, CT
11.	John R. Casmer	Greenwich High School, Greenwich, CT
12.	Jim W. Hodrinsky	Enrico Fermi High Schoo, Enfield, CT
13.	John Filipvzak	Norwich Reg. Vo-Tech School, Norwich, CT
14.	E.G. Morris	H. Wilcox RVTS

APPENDIX B

PARTICIPANTS

NAME	SCHOOL	TOWN
Bevis, Stuart	Portland J.H.S.	Portland
Billings, Bruce	Avon Old Farms	Avon
Boyle, Lawrence	Oliver Wolcott R.V.T.S.	Torrington
Britland, Edmund	Oliver Wolcott R.V.T.S.	Torrington
Burns, Gregory	Simsbury H.S.	Simsbury
Coffman, Douglas	Oliver Wolcott R.V.T.S.	Torrington
Cooner, Alice	Choate School	Wallingford
DiChristofaro, Ezio	Kennedy J.H.S.	Southington
Fairchild, Dick	Hartford Public H.S.	Hartford
Gillman, Thomas	Shepaug Valley	Washington
Garner, Wally	Hartford Public H.S.	Hartford
Ingellis, Patrick	Xavier High School	Middletown
Jones, Stewart	Torrington H.S.	Torrington
Konefal, Charles	Wilcox R.V.T.S.	Meriden
Muller, Kenneth	Torrington H.S.	Torrington
O'Neil, Barbara	Eastern J.H.S.	Greenwich
Ranker, Rachel	Hamden High School	Hamden
Rodrigues, Peter	C. C. S. C.	New Britain
Rodrigues, Roy	Amity Reg. H.S.	Woodbridge
Rosolowski, Florence	Conrad High School	West Hartford
Schack, Lenore	Berlin High School	Berlin
Serbin, John	Hartford Public H.S.	Hartford
Skerker, Art	Hartford Public H.S.	Hartford
White, Craig	Simsbury H.S.	Simsbury
Ziegra, Albert	Institute of Living	Hartford

MODEL SOLAR ENERGY TRAINING PROGRAM

CURRICULUM GUIDE

PREPARED BY:

TALCOTT MOUNTAIN SCIENCE CENTER FOR STUDENT INVOLVEMENT, INC.

MONTEVIDEO ROAD - AVON, CONNECTICUT

PREPARED FOR:

CONNECTICUT STATE DEPARTMENT OF EDUCATION

DIVISION OF VOCATIONAL EDUCATION

BUREAU OF VOCATIONAL PROGRAM PLANNING & DEVELOPMENT

HARTFORD, CONNECTICUT 06115

PROJECT DIRECTOR: DR. DONALD P. LA SALLE, DIRECTOR
TALCOTT MOUNTAIN SCIENCE CENTER

STAFF: GEORGE C. ATAMIAN
ROBERT S. AMREIN
JONATHAN R. CRAIG
EDWARD MORRIS
PHILIP FINE

This project was supported by funds available to Connecticut through the Vocational Education Act of 1976. Public Law 94-482.

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TABLE OF CONTENTS

COLLECTOR EXPLORATION #1	1
INSULATION	3
GLAZING	6
ABSORPTION MEASURING HEAT OF COLLECTOR WITH A THERMOCOUPLE	9
COLLECTOR EXPLORATION #2	12
COLLECTOR EXPLORATION #3	14
COLLECTOR EXPLORATION #4	16
PLUMBING AND INSULATION	20
PLUMBING AND PIPES	21
A SOLAR INSTALLATION SITE PLAN	25

COLLECTOR EXPLORATION #1

SOLAR IN A COFFEE CAN

OBJECTIVE: This experiment is meant to familiarize the student with solar energy. It allows the student to perform a simple experiment by building a collector, collecting the sun's rays and measuring the heat converted by this process. The effects of glazing and insulation will be introduced in this experiment

TEACHER BACKGROUND:

A solar collector has five basic parts. Each will be investigated in this activity.

One major part of a collector is a covering material, called glazing, which transmits as much solar energy as possible. Its purpose is to trap the energy it transmits inside the collector. The glazing should be able to withstand high temperatures without decomposing or melting, and it must be able to withstand impact from objects that might fall on it.

Another part of any solar collector is the collector plate which absorbs the energy transmitted by the glazing. The collector plate is usually coated with a dark colored material that increases the absorbance of the solar energy. The collector plate and its coating must be able to withstand high temperatures without vaporizing or otherwise breaking down. The collector plate is often made from copper or aluminum but other materials may be suitable.

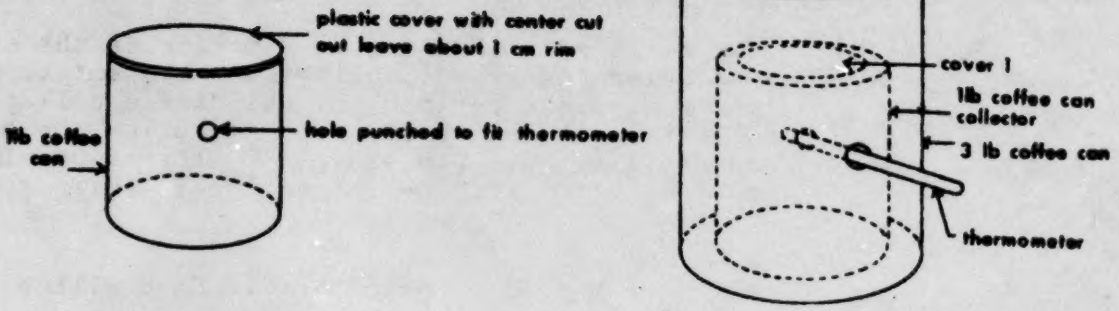
A third part of the collector, the collector box, houses the various parts of the collector. It can be made from material such as aluminum, wood fiberglass or steel. It must be sturdy, able to withstand temperature extremes and weather conditions.

A fourth part of the collector is the insulation that surrounds five sides of the collector box. Conduction losses of trapped solar energy are substantial unless the collector box is well insulated. Fiber glass and various foams are commonly used for this purpose.

The fifth part of a collector is air or a liquid. It is used to transfer the solar energy to a system for distribution throughout the space to be heated or to a substance to be heated. If water is used as the medium in cold climates, it is often mixed with an antifreeze.

A collector or a series of collectors can be used for space heating or to provide hot water for commercial or domestic uses.

Several weeks before the activity is planned, have students start bringing in one and three pound coffee cans with or without plastic lids.


plastic cover with center cut out leave about 1 cm rim
1lb coffee can
hole punched to fit thermometer
cover 2 (if used)
cover 1
1lb coffee can collector
3 lb coffee can
thermometer

PROCEDURE:

1. Spray the inside of the smaller can with black paint.

2. Punch a hole in the side of the small can to fit the thermomet

3. Punch a hole in the outer can so that the thermometer can pass through it. Allow for the insulation being placed in the outer can. Small can will rest on this, not on the bottom of the outer can. Holes could be pre-punched in the cans by someone other than the students. (Use a metal punch to form the holes with an appropriate backing to avoid bending the can.) Or insert thermometers through both layers of plastic and into the center can.

4. Cut the center out of the small can's plastic lid, leaving a 1 cm rim. (See diagram above.) Use masking tape to secure the plastic to the can.

5. Choose one of the cover materials to stretch across the top of the smaller can. Hold the material secure by replacing the cut out plastic lid.

6. Put the small can inside the larger can after wrapping the smaller can with insulation.

7. Insert the thermometer through the hole in the large can and then fit it snugly into the smaller can.

8. Place the collectors in the sun and record the temperature at one-minute intervals for fifteen minutes.

9. The students may plot their data on graphs as a function of time vs. temperature comparisons of glazings and insulation types may be domonstrated in this way.

INSULATION

OBJECTIVE: Students will learn about various types of insulation and will understand current applications and limitations of their use.

TEACHER BACKGROUND:

With energy becoming an ever-increasing problem, we are continually searching for new ways to stretch our energy dollars. At present, the most cost-effective means is through the proper use of insulation. There are many forms of insulation available on the market at a variety of prices. This experiment will help students understand the uses of insulation and help them make wise decisions for their energy future.

Building suppliers and contractors often have left-over portions of insulation products which may be purchased or even donated to a good cause. After accumulating a variety of types of insulation, develop a chart with the class listing the insulations and leaving space for their uses. List each insulation material with its rated R-value per inch (if costs are available, this comparison may also be made).

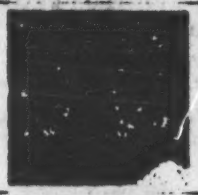
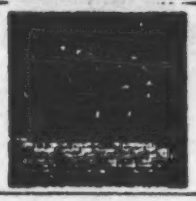
Here is a list of common insulators with R-values* per inch:

	R-value
Fiberglass batt	3.1
Fiberglass fill	2.2
Rock wool batt	3.9
Rock wool fill	2.7
Closed cell blue styrofoam	6.5
Styrofoam board	4.5
Polyurethane foam	4.5
Isocyanurate foam	7.3
Urea formaldehyde (Due to shrinkage following installation, actual R value is slightly less.)	4.2
Cellulose fibrefill (contains boric acid)	3.7
Vermiculite	2.2
Perlite	2.7

*R-value = resistance to heat flow ($BTU/hr/F^{\circ}/ft^2$).

Discuss possible uses for all insulations such as building exteriors and interiors, hot-air duct work, plumbing for heating systems and solar applications. Discuss what makes a good insulator.

Types of insulation

Form		Method of Installation	Where Applicable	Advantages	Materials
Blankets or Batts		Fitted between wood-frame studs, joists, and beams	–All unfinished walls, floors, and ceilings	–Do-it-yourself –Best suited for standard stud and joist spacing, which is relatively free from obstructions –Blankets: Little waste because it's handcut –Batts: More waste, but easier to handle than large rolls	Rock wool Glass fiber
Loose Fill (poured in)		Poured between attic joists	–Unfinished attic floors and hard-to-reach places –Irregularly shaped areas and around obstructions	–Do-it-yourself –Easy to use for irregularly shaped areas and around obstructions	Rock wool Glass fiber Cellulose fibe Vermiculite Perlite
Blown Fill		Blown into place by special equipment	–Anywhere that frame is covered on both sides, such as side walls –Unfinished attic floors and hard-to-reach places	–The only insulation that can be used in finished areas –Easy to use for irregularly shaped areas and around obstructions	Rock wool Glass fiber Cellulose fib Urea-formal foam (not recommend unfinished a
Rigid Insulation		Must be covered with ½-inch gypsum board or other finishing material for fire safety.	–Basement masonry walls –Exterior walls under construction	–High insulating value for relatively little thickness	Polystyrene Polyurethan Isocyanurate

Source: DOE Insulation Fact Sheet

PROCEDURE:

1. Test under hood or outdoors each type of insulation in an open flame (Bunsen burner or small torch). Note that some types give off black smoke and burn readily. What does this tell the student about where an insulation may or may not be used? (Many victims in large hotel fires died from noxious insulation fumes.)

2. Heat a hot plate (solid plate burner) or electric iron to 200°F and touch a piece of each insulation material to it. (Vinyl and polystyrene should melt). In many heating systems and solar applications 200° may be reached, although often with water systems the temperature is kept below this to prevent steam and overpressure of the system. Increase the heat source to 350°F and fiberglass with bonding material will outgas and urethane and isocyanurate will begin to break down.

In collector systems, temperatures may reach above 350°F so high-temperature fiberglass without bonding agents and isocyanurat with foil backing are often used in collectors.

3. Fill a glass or plastic container with water. Weigh a small portion of each insulation then submerge it in water, weighing

again after submersion. Those insulations that absorb water will become ineffective in exterior applications. Test urethane and isocyanurate last. Using litmus paper, test the water from these two insulations. (Litmus will turn red as they form an acid.)

4. As a long term experiment (3-4 weeks), leave insulation exposed to sunlight and determine degree of breakdown.

5. Summarize properties and discuss proper applications for each insulation and use R-value and cost comparisons to determine most economical uses.

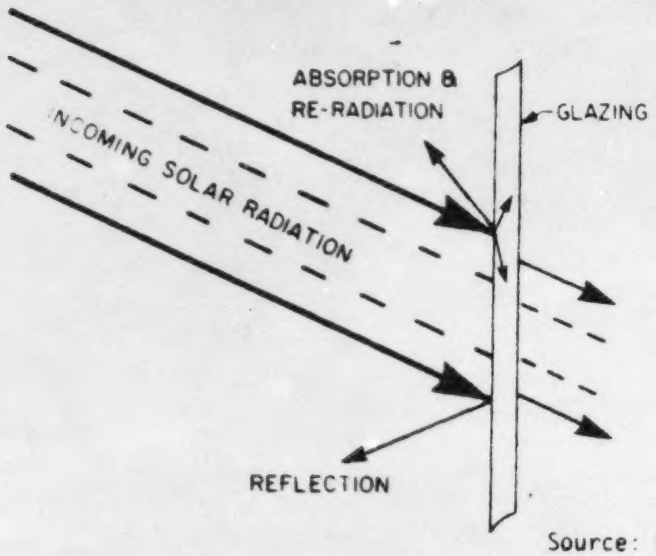
GLAZING

OBJECTIVE: The student will be able to test a variety of glazings for transmisivity and the various properties related to heat and solar exposure.

TEACHER BACKGROUND:

As we learn more about using the sun's energy, windows and solar collector glazings become more significant. Any form of glazing has very little merit as an insulator (R-value = .9). Glass is used for coffee pots and other cooking devices indicating its conductive qualities. In warm weather climates, single glazing or even just a screen may be adequate to keep comfortable. However, in northern temperate climates such as our own, another layer of glass means twice the protection from the outside cold and in some instances, three layers may be recommended.

TRANSMITTANCE LOSSES



Source: Northeast Solar Energy Center

Glazing comes in many different types, each having favorable and unfavorable characteristics such as breakability, resistance to heat, durability against weather and weight and transmisivity. As in the insulation activity, a chart can be made listing the properties of each type of glazing.

Many different types of glazings can be obtained from storm door and window manufacturers for a nominal fee or perhaps even donated. (See List)

COMPARISON OF GLAZING MATERIALS

GENERAL TYPE	TRADE NAMES	THICKNESS (inches)	SOLAR TRANSMITTANCE (%)	IR TRANSMITTANCE (%)	MAXIMUM OPERATING TEMPERATURE (°F)	ESTIMATED LIFETIME (years)	$/SQUARE FOOT	TRANSPARENT	TRANSLUSCENT	POUNDS/SQUARE FOOT
Glass	Double Strength	.125	84	<3	400+	25+	1.00	X		1.60
	Insulated Units	.625	71	<3	200	25+	3.50-7.00	X		5.
	Sunadex Lo-Iron	.187	91	<3	400	25	2.25		X	2.4
Acrylic	Plexiglas, Lucite, Acrylite	.125	89	<5	180-200	20+	2.00	X		.73
	Double Wall: Exolite SDP	.625	83	<5	160	20+	3.00-4.00		X	1.
Polycarbonate	Lexan Merlon	.125	87	6	270	10-15	3.25	X	X	.75
	Double Wall: Tuffak-Twinwall	.220	79	<8	270	5-7	1.75-3.00		X	.25
Fiber Reinforced Polyester	Lascolite	.040	81	<10	160	15	.60		X	5 oz.
	Filon	.040	82		160	15	.85		X	4 oz.
	Kalwall	.040	85		200	12	.85		X	5 oz.
	Double Wall: Kalwall	1.500	70		N/A	12	5.00		X	N/A
Laminate: Acrylic/Polyester	Flexigard	.007	89	9.5	275	10	.40	X		5 oz.
Polyethylene	Visqueen	.006	85	>70	120	8 mos.	.02		X	.5 oz.
	Monsanto 602 (U.V. Resistant)	.006	87		<160	2-3 yrs.	.08		X	.5 oz.
Polyester	Mylar	.001-.035	85	50	250	2	.08-.35	X		.25-.10 oz.
	Llumar (U.V. Resistant)	.0005-.014	88	N/A	350	10	.50	X		
Fluorocarbons	Tedlar PVF	.004	90	50	300	10	.50		X	.5 oz.
	Teflon FEP	.061	96	50	400	25	.50	X		
Silicone Coated Cloth	Dow Corning	.008	90	10	500+	15+	1.00		X	.5 oz.

*Revised from SOLAR ENERGY ADULT EDUCATION CURRICULUM NESEC 1980
Reprinted from "Thermal Storage Wall Design Manual" by Alex Wilson

GENERAL TYPE	ADVANTAGES	DISADVANTAGES
Glass	Excellent Transmissivity Characteristics; Superior Resistance to Heat, U.V., Abrasions; Low Thermal Expansion/Contraction; Easily Available; Transparent.	Difficult to site fabricate; Low Impact Resistance; Cost.
Acrylic	Excellent Transmissivity Characteristics; Superior U.V. & Weather Resistance; Won't Yellow; Lightweight; Easy to Site Fabricate.	Susceptible to Abrasions High Expansion/Contraction Rate; Slight Embrittlement with Age; Cost; Relatively Low Service Temperature.
Polycarbonate	Excellent Service Temperature; Highly Resistant to Impacts.	Poor Weatherability & U.V. Resistance (Yellows); Scratches Easily, Not Easily Available; High Expansion/ Contraction Rate.
Fiber Reinforced Polyester	Low Cost; High Strength; Superior Weatherability (Tedlar coated panels only); Easy to Fabricate and install.	Susceptible to U.V., Dust & Pollution Degradation; Yellows with Age; High Expansion/Contraction Rate.
Laminate: Acrylic/Polyester	Combines Weatherability of Acrylic with High Service Temperature of Polyester; Good Transmissivity Figures.	Non Reversible; Susceptible to Wind Flapping.
Polyethylene	Inexpensive; Easy to Install; Easily Available.	Poor U.V. and Weather Resistance; Low Service Temperature; Cats LOVE to climb on the stuff.
Polyester	Low Cost, Clear Glazing; High Service Temperature.	U.V. Degradable Unless Treated; Optical Clarity is Distorted due to Thinness of Material.
Fluorocarbons	Excellent Weatherability; Strong; High Solar Transmission; High Service Temperatures; Long Life.	High I.R. Transmission; Not Easily Available; Susceptible to Wind Flapping; Poor Tear Resistance.
Silicone Coated Cloth	Good Transmissivity Characteristics; Excellent Service Temperature; Extremely Weatherable.	Susceptible to Wind Flapping and Tearing.

*Revised from SOLAR ENERGY ADULT EDUCATION CURRICULUM NESEC 1980
Reprinted from "Thermal Storage Wall Design Manual" by Alex Wilson

ABSORPTION MEASURING HEAT OF COLLECTOR WITH A THERMOCOUPLE

OBJECTIVE: A student will be able to test the properties of different absorber materials and the absorbancy of different colors for solar collectors.

TEACHER BACKGROUND:

Copper is the most widely used material for solar absorbant surfaces. This material is compatible with standard plumbing practices and is a good conductor of energy. Other materials have been used with limited success such as aluminum, galvanized sheet metal, plastics and rubber mats. Future projects seem to be leading toward thin polymer metal combinations which will have little or no possibility of corrosion or breakdown. Surfaces of the absorbers may be chemically bonded or have etched surfaces such as selective black nichrome or selective paints. Selective surfaces not only have good absorbancy qualities, but also have a low emisivity or rate of reradiation. Students may test different colors and gloss vs. flat colors. Each paint has its own set of properties so no one factor can determine its performance on the absorber surface.

This experiment uses a thermocouple to measure heat. Thermistors similar to this are used in solar collectors to trigge the differential thermostat mechanism in a solar system controller

A thermocouple is made up of two different types of wire twisted together. Heat added to this coil creates an electrical current. Using two coils with one at a given reference temperatur temperature can be easily determined. A table for temperature readings (0°C or 32°F) of a copper constantan thermocouple using ice water as the reference temperature is given below. Other thermocouple combinations may be used but a different table must be used for your results. Copper constantan is one of the most common combinations and most suitable for the temperature range of this experiment.

TEMPERATURE - VOLTAGE READINGS FOR A COPPER - CONSTANTAN THERMOCOUPLE

°F	°C	MILLIVOLTS	°F	°C	MILLIVOLTS
0	-17	-.67	110	43	+1.75
10	-12	-.47	120	49	+1.99
20	-6	-.26	130	55	+2.23
30	-1	-.04	140	60	+2.47
32	0	.00			
40	5	+.17	150	66	+2.71
50	10	+.39	160	71	+2.96
60	15	+.61	170	77	+3.21
70	21	+.83	180	82	+3.46
80	27	+1.06	190	88	+3.71
90	32	+1.29	200	93	+3.97
100	38	+1.52	210	99	+4.22
			400	190	+20.00 max r

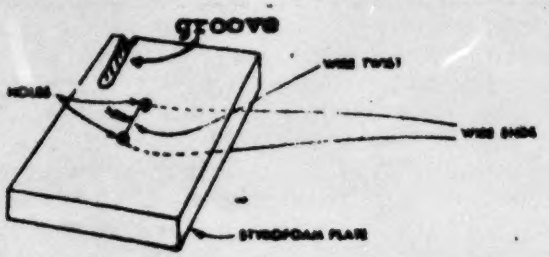
PROCEDURE:

Each group will need one meter of copper/constantan thermocouple wire, a millivolt meter, a piece of styrofoam (5cm X 60cm X 60cm), a metal absorber 60 X 60 cm (copper flashing, aluminum flashing or foil, galvanized steel, or sheet metal may be used.) Try to determine what effect metal thickness has on absorber efficiency.

1. Carefully take the piece of copper wire and cut it into two pieces, one slightly longer than the other.

2. Take the end of the longer copper wire and twist it together with the constantan wire so that about ten tight turns are made (you may need pliers).

3. With a nail, make two holes in the sheet about 2 cm from each other and near the center. Feed the ends of the twisted wire through the holes as far as they can go without untwisting the two wires. (See figure 1) Also cut small groove to fit thermometer



4. Take the end of the constantan wire which is not twisted and twist it together with the smaller piece of copper wire in the same fashion that you used in step 2.

5. Place this twist in the insulated container filled with ice and water. It helps to make a styrofoam cover to improve the insulation of the container.

6. Paint aluminum with black spray paint on one side.

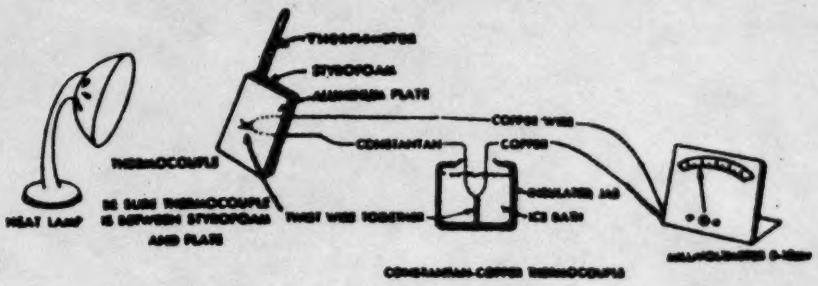
7. Carefully glue (in 2 or 3 spots only) the aluminum foil to the outside of the styrofoam sheet, painted side up, to serve as an absorber plate. Be careful not to rip the aluminum foil on the rough edges of the wire. Test surfaces other than aluminum foil such as copper sheeting, galvanized steel, or sheet metal. Use colors other than black and compare your results.

8. Place the voltmeter between the two copper wires that are not attached. If the voltmeter does not read a value, switch the

terminals so that the volt reading is positive. (See figure 2)

9. CAREFULLY take your equipment outside. (If no sun is available use heat lamp inside).

10. See figure 2 for an illustration of this activity.



11. On a data sheet, record the voltage reading every minute for fifteen minutes.

12. Carefully take your equipment apart so that all the pieces may be used again.

13. Using the conversion scale, determine the approximate temperatures which your collector had during each interval that you measured. Place this beside your voltage reading on your data sheet.

14. Plot the data, temperature vs. time on a graph.

15. Insert thermometer in groove behind plate and record the actual temperature vs. the calculated temperature.

COLLECTOR EXPLORATION #II

HEAT LOSS AND STORAGE IN A SIMPLE SOLAR GREENHOUSE

OBJECTIVE: The student will be able to build a simple testing structure. From this apparatus, the student will learn the principles of the "greenhouse effect" and be able to test different materials for thermal storage.

TEACHER BACKGROUND:

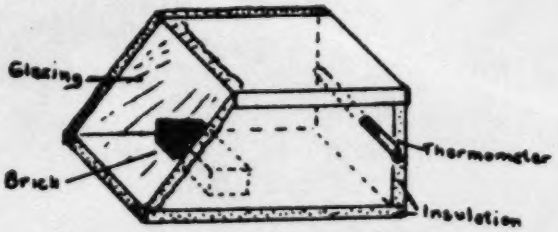
All solar heating systems utilizing sunlight must convert that energy through a process called the "greenhouse effect". Simply stated, light energy trapped in a solar collector is absorbed. The absorbing surface reradiates this energy in a longer wave-length (infrared) and the infrared energy is trapped by the glazing with only a portion escaping. This trapped energy is then reabsorbed as heat in the collector

A greenhouse, then, is a form of solar collector constructed so that all of its glass heat may escape through conduction. When the sun does not shine, the greenhouse's losses will be greater than its gains and it will get colder than most plants can stand. Many greenhouses bring in more energy than they can use during a sunny winter period and the excess energy is vented to the outside. Materials placed in the greenhouse to absorb this excess energy and later redistribute it at night may help us better utilize the sun's energy.

PROCEDURE:

Collect materials such as concrete or broken cinder block, brick, small stones and cans or film canisters filled with water. Discuss density, thermal mass and specific heat as factors for heat storage.

1. Construct a greenhouse using a shoebox or similar size cardboard container. See Diagram.



Greenhouse

2. Insulate all sides of your box with 1" styrofoam or fiberglass

insulation around the outside.

3. Paint the inside flat black and cover the diagonal opening with 5mil plastic sealed to the box. The top should be made moveable in order to replace storage materials.

4. Place the box in sunlight or under a lamp. For ten minutes, record the temperature from the thermometer in top of box (out of direct sunlight) at one-minute intervals. Shade the box for 10 minutes and continue to record the temperature at one-minute intervals. The temperature should fall quickly.

5. Try each type of storage material in the box where sunlight can shine on it directly. Again test for 10 minutes.

6. Determine which storage holds the most heat for the longest period of time, whether water is better than stone, and if solid blocks are better than fragments.

COLLECTOR EXPLORATION #III

BUILD A SIMPLE HOT AIR COLLECTOR

OBJECTIVES: Students will be able to build and test a simple air flow collector. Information found in previous experiments will help the student to make better judgments in this one. Students will evaluate their collectors for heat output and efficiency.

TEACHER BACKGROUND:

The solar collector is a device for transforming light energy to heat energy and thus raise the temperature of the transport medium. Visible light rays enter the collector through glazing material. Upon striking the absorber plate, some of these rays are absorbed as heat and others are absorbed and reradiated as longer wavelength infrared rays. A black surface increases the efficiency of the process, while the insulation and glazing keep these heat rays inside the collector. The input hole allows outside air in. This air is heated while inside the collector and because hot air is less dense, it will rise and escape by convection through the upper hole for output. When properly functioning, the flat plate air flow solar collector will have an output air temperature substantially higher than the input temperature.

Any solar collector regardless of size or complexity always contains the following five elements: a collector box, glazing, an absorber plate, insulation, and heat transfer medium such as air, water, etc.

Students may build collector box or teacher may supply a pre-fabricated one to be used for future classes. If possible, make available a variety of glazing and insulation materials in order to allow students to make decisions based on previous experiments.

PROCEDURE:

1. Build a box of 1/4" to 1/2" plywood or pine, 4" deep and 12" wide and 16" long as inside dimensions. Cut insulation to fit 12 x 16 dimensions.

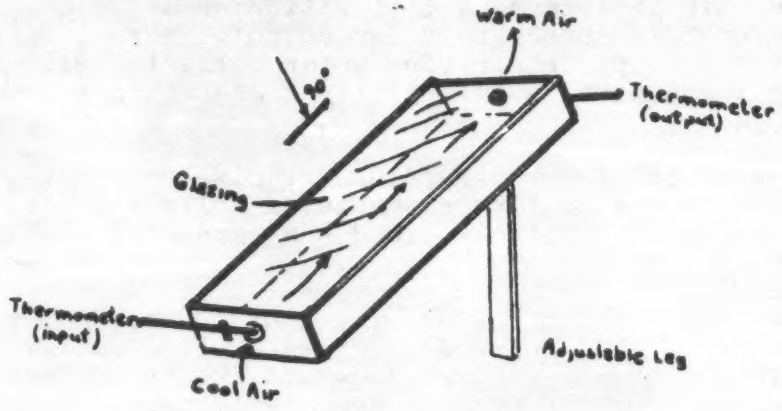
2. Cut glazing slightly larger to overlap sides. Drill a 1" hole centered in either end of the box. Absorber may be foil backing on insulation or aluminum foil cut to fit.

3. Paint the absorber surface and assemble the collector.

4. The glazing may be taped with masking tape and a thermometer should be taped in place at each hole to record input and output temperatures. Students should take extreme care if glass laboratory thermometers are used. Thermometers with a range of -10° to 110°C or 20 to 220°F provide an adequate range for outdoor winter and summer conditions.

5. Place collector in sunlight and adjust to an optimum angle to obtain the most sunlight. The angle perpendicular to the sun will change throughout the day and year. Tests could also be made with collectors facing south at an angle best suited to winter (latitude +10°).

6. A reading should be taken from each thermometer every two minutes for at least 20 minutes. Shorter periods may be used but will not show maximum performance. Collector data may be graphed with an axis for time and temperature.



41

COLLECTOR EXPLORATION #IV

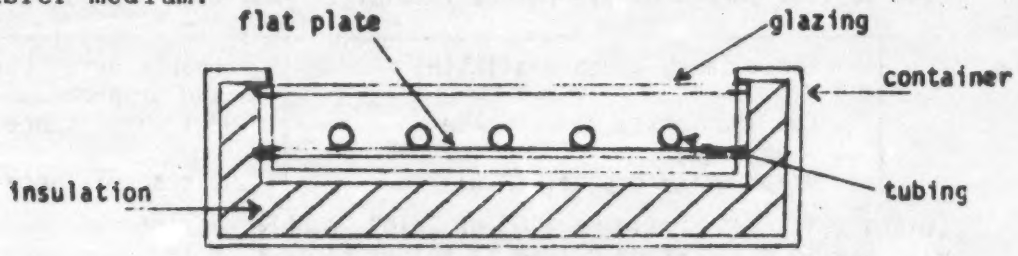
SOLAR HOT WATER

OBJECTIVE: Students will learn the principles of heating water with a flat plate solar collector, properties of water storage and thermosiphoning are also explored.

TEACHER BACKGROUND:

From previous experiments, the students will have developed tables of materials used in solar collectors. Now all of the components may be assesbled. Decisions regarding which materials are to be used may be made as a class or by instructor previous to class based on availability.

Many different designs have been developed for flat plate collectors. Basically, the flat plate collector is a device which absorbs the energy falling upon it and transfers this energy to the transport medium. No attempt is made to concentrate the sun's energy on a smaller area; as a result, the maximum operating temperature of the fluid in a flat plate collector is usually less than 65°C (150°F). The collector consists of an enclosure, insulation, glazing and a flat plate with tubing to carry the heat transfer medium.



Schematic Diagram of Cross Section of Flat-Plate Collector

The surface area required of the solar collector varies with geographic location. A very rough rule of thumb is a one to three ratio of collector area to living space. In the colder regions of the country it is still not economical to rely on solar heat for more than 50 percent of the total space heating required. Domestic hot water heating by solar energy is competitive at present with electric hot water systems in much of the country. Solar collectors now cost roughly $\$10/ft^2$; entire systems \$20 to $\$40/ft^2$. Costs, however, are subject to rapid change. Systems integrating solar cooling with solar heating may require the concentrator-type collector because of the need for water temperatures of 93°C (200°F) or more.

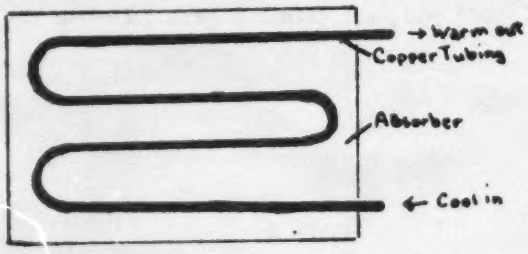
MATERIALS USED IN FLAT PLATE COLLECTOR CONSTRUCTION

COMPONENT	MATERIALS USED	COMMENTS
Container:	Metal (Aluminum, galvanized steel)	Lightweight, durable.
	Fiberglass Plastic	Many plastics deteriorate rapidly on exposure to ultraviolet radiation.
	Wood	May deteriorate because of high stagnation temperature (350°F) and moisture condensation.
	(There is no standardized size for single units: a 4 x 8 ft. unit is difficult for two persons to handle: 4 x 4 ft. units are often used. 2 x 3 ft. units may be used to take advantage of local availability of this size sheet metal.	
Insulation:	Fiber glass (glass wool)	Has relatively high insulating value, stable.
	Polyurethane foam	Expensive, deforms over 160°F.
	Styrofoam	Flammable.
	(Two to four inches of fiberglass insulation should be used.)	
Glazing:	Glass (many types available)	Probably best, but costly and breakable.
	Low iron glass (looks blue on edge)	.88 transmittance, common.
	Water white crystal (ASG)	.92 transmittance, costly.
	(Glass thickness should be 1/8" or 3/16"; double glazing with one inch air space needed in colder regions or if temperature over 160°F are desired.)	
	Fiberglass ("Filon", "Kalwall")	Good, but some loss of transmittance with ultraviolet aging (special ultraviolet resistant types available at higher cost.)
	Polycarbonates ("Lexan")	Good, but very expensive.
	"Mylar", "Tedlar" sheeting	Reradiate infrared; mylar undergoes ultraviolet degradation.
	Polyethylene Film	Poor, short life (1/2 yr.) transmits up to 70% infrared (this represents a heat loss.)
Flat Plate:	Copper	Probably best.
	Aluminum	Corrosion problems if contact with other metals.
	Steel, galvanized	Poorer heat conduction, may rust eventually.

COMPONENT	MATERIALS USED	COMMENTS
Tubing:	Copper Aluminum Plastic	Best. Possible corrosion problems. Poor heat transfer, low temp. use.
Paint:	3M "Nextel" or "Black Velvet" Flat Black	.98 absorptivity with 93. emissivity, expensive. Should stand 400°F
Selective Coating:	Black Chrome Nickel Black Black Copper Oxide	Best, durable, .90 absorptivity and .15 to .35 emissivity, but very expensive.
(Selective coatings increase efficiency dramatically when there is a large temperature difference between the collector plate and outside air. For low temperature collectors the extra cost is probably not warranted.)		
If the heat transfer medium is air instead of liquid, then no tubing is required and just the flat or corrugated sheet, with or without baffles, is used.		

PROCEDURE:

1. Depending on age and skill level of students the absorbers can be made previous to class by the instructor or as part of the activity. A 12" x 16" absorber may be cut from galvanized steel or sheet copper. Make a serpentine pattern on the absorber with a pencil (See diagram).



2. Bend 5 ft of soft copper 1/4" or 3/8" tubing using a tubing bender on a flat table into the pattern indicated above. Allow 2 inches on each end for connection of rubber tubing.

3. Take a one-pound coffee can and drill holes in the sides and top and bottom to accommodate small nipples (2" each) cut from copper tubing.

4. Using a flux and 60-40 or 50-50 solder copper tubing onto plate.

Expansion and contraction during heating will cause plate to buckle. To minimize this, clamp tubing to the plate at 10-inch intervals or as needed. Make sure soldering is done on a non-flammable surface.

5. After absorber is soldered, solder nipples into can, allowing them to project 1/4" inside can. Check for leaks.

6. Cut insulation 12 x 16 and glazing slightly larger. Construct a box the same as in the previous activity. Drill holes to accommodate ends of tubing from absorber plate. Box sides may be slotted to accommodate absorber plate and glazing or absorber may rest on insulation with glazing taped on top of the box.

7. After collector is assembled, attach 2 feet of rubber tubing to the bottom of the can and the bottom of the collector. Attach a second piece to the top of the collector. (Can must be above collector.)

8. Place collector in sunlight or under a heat lamp. Fill can with water and collect heated water at top in a second container of same size. Measure temperature in top and bottom cans. Temperature may be increased by pouring heated water through several more times. The average temperature change (T) may be calculated for each cycle. (Bottom input - Top output = T.)

THERMOSIPHON METHOD

1. Connect rubber tubing from the top of the storage to the top of the collector and fill the storage container to above the top fitting.

2. Allow to stand in sunlight for 20 minutes.

3. Record the temperature change every 2 minutes. Storage must be above the collector in order for the thermosiphon to circulate. Also, the collector should be tipped back and forth to allow any air to escape from tubing. The storage tank should be insulated for better efficiency. Make comparisons to a domestic hot water system.

PLUMBING AND INSULATION

OBJECTIVE: This demonstration will show the student the properties and proper use of different insulations for application to solar plumbing situations. Students will have already tested these materials for heating and weathering properties in a previous session.

TEACHER BACKGROUND:

Plumbing insulation is one of the most commonly overlooked or improperly installed materials in a typical solar installation. As demonstrated in a previous activity, many insulations cannot stand up to high temperatures which may be reached under conditions of stagnation in a solar heating system. Many types breakdown in ultra violet light, others are not water resistant and when wet may produce corrosive materials which may react with plumbing. Manufacturers of plumbing insulations have solved many of these problems, but care still must be exercised when selecting insulations. Most insulations are applied with a protective plastic covering with a tight seal for exterior uses.

In a solar hot water system all exposed pipes except for cold water supply should be insulated. All hangers should be isolated from pipe by insulation since each may act as a potential heat sink.

The most common pipe insulation materials are fiberglass, eslatomers, (Armaflex, Rubatex, etc), urethane, and isocyanurates. As shown previously application depends on availability, cost, insulating qualities, and durability of materials.

Covering materials may be a plastic or aluminum jacket or in some cases just paint will be enough. Aluminum and plastic covers are most often pop-riveted and sealed with silicone and or weather resistant tape (duct tape should not be used for this purpose).

PROCEDURE:

INSULATION PLUMBING

1. Prepare a board showing major pipe insulation systems. Demonstrate by passing samples around. Discuss sealing, fastening, tapes, hangers.
2. Emphasize importance of insulation. Discuss minimum thickness inside and outside for pipes; durability and costs of the recommended insulation.
3. Extend discussion to storage tank, including installation techniques. Show polystyrene foam and the way to use it as a second layer on storage tank.
4. Discuss underground lines. Show sample of pre-insulated pipe for underground use. Elastomerics should not be used for underground applications.
5. Set up an insulated tank and fill with hot water. Find its time constant and calculate the heat loss coefficient.

PLUMBING AND PIPES

OBJECTIVE: Students will know the different types of plumbing used in solar applications. They will discover what electrolysis and galvanic action are and will learn proper solder use and techniques.

TEACHER BACKGROUND:

Plumbers have followed many common sense guidelines for years, but in many solar applications these guidelines have been overlooked or perhaps need modification to meet the new applications of a solar hot water system. One rule of thumb is not to mix unlike metals. Still many solar systems have cast iron pumps mixed with copper plumbing. Some collectors have used aluminum and copper together resulting in very short life of the system. Use the accompanying table to explain electrical potentials of metals. Galvanic action is a process by which one metal is attracted to and plated on to another. Water by itself is not a good conduct r, but with acid fluxes, and chemical changes in a solar system galvanic action and oxidation can cause major problems with a system.

GALVANIC SERIES OF METALS

Anodic or Least Noble End

GROUP	METAL
a.	Magnesium
b.	Zinc
c.	Aluminum 2S
d.	Cadmium
e.	Aluminum 6063 -
f.	Steel Iron Cast Iron
g.	18-8 Stainless Steel (active)
h.	Hastelloy
i.	Lead/tin solder Lead Tin
j.	Nickel (active)
k.	Brass Copper Bronze Copper Nickel Alloys Monel
l.	Silver solder
m.	Nickel (passive)

RECOMMENDED TYPES OF PLUMBING

The most favored plumbing for solar DHW systems is sweat-soldered, L-type copper tubing. M-type copper is also acceptable if it is allowed by local building codes.

All joints in copper tubing in and near the collector array should be soldered with 95-5 tin-antimony solder to avoid joint failure at stagnation temperature. While 95-5 could be used throughout the rest of the system and should be used in a silicone system, 50/50 tin-lead solder can be freely substituted in those parts of the system that will not be subjected to the extremes of stagnation temperature. Remember that silicones and glycols demand well-soldered joints.

The following table indicates common solder types and their respective melting temperatures and metalic makeup.

TIN	LEAD	ANT	SOLID	LIQUID
63	37		361	361
60	40		361	374
50	50		361	421
45	55		361	441
40	60		361	460
95		5	452	464
Melting point of solder			Paste range	

Although soldered joints are preferred, threaded joints may be made with a good quality joint compound and/or Teflon® tape. Examples of quality joint compounds are: Loctite® pipe dope with Teflon® (Part No. 529), Crane® Je-30 pipe thread sealer with Teflon®, Rector® Seal No 5, and Dow Corning® 730 Fluorosilicone rubber sealant, and their equivalents.

CAUTION: If the heat transfer fluid is a silicone or a water/glycol solution, standard pipe dope WILL NOT prevent leakage.

PLASTIC PIPE

Do not use PVC for hot water applications. CPVC will sag about 160° F, if not adequately supported, thereby preventing draining of draindown systems, making flushing out of non-draindown systems more difficult, and preventing air bubbles from venting properly. Polybutylene pipe will begin to sag at about 200° F. In general, use extra care when using plastic pipe.

GALVANIZED THREADED PIPE

Convential galvanized threaded pipe may be used if already installed in the existing DHW system. All threaded joints should be thoroughly pipe doped.

SILICONE COUPLING HOSES

Silicone coupling hoses are sometimes recommended by the manufacturer for connecting collectors to the array manifold or to act as expansion joints in the hot water return circulation. Those hoses can also be used between plumbing of dissimilar metals to retard galvanic corrosion.

CAUTION: Ordinary automobile radiator hoses should never be used, as they break down rapidly when exposed to the ultra violet waves in sunlight.

Silicone hoses should be clamped with lined stainless steel hose clamps without the usual perforations. The rubber will extrude through the perforations.

HANGING AND ANCHORING PIPE

Pipe hung vertically should be anchored at the following intervals:

Copper Tubing - one story or ten-foot intervals

Threaded Pipe - every other story

Rigid Plastic Pipe - half-story intervals

Pipe hung horizontally should be supported at the following intervals:

Copper Tubing - eight-foot intervals for drawn tube, six-foot for annealed tube

Threaded Pipe - twelve-foot intervals

Rigid Plastic Pipe - one-to-two foot intervals

EXPANSION - All pipe should be hung or anchored loosely enough so that it can expand and contract with temperature changes. A 100' length of copper pipe will expand approximately 1" with a 100° F. temperature rise. Using silicone hoses as expansion joints is advised in arrays where there is no room for pipe expansion. Standard corrugated expansion joints made of copper alloy are also available. Elbows will also allow for some expansion.

INSTALLATION TIPS - Keep insides of all tubes or pipes clean and ream out the ends of all pipes and tubing. Sandpaper or emery cloth the outside surface of the ends of copper tubing and the inside surface of all copper fittings before soldering. Surfaces must have a bright finish. Bend copper tubing (providing it is annealed or bending temper tubing) rather than use elbows or other fittings. This will reduce friction losses. Avoid sharp bends and use bending tools. Use eccentric reducers to join horizontal pipe of different sizes and avoid trapping air (Figure 3.1).

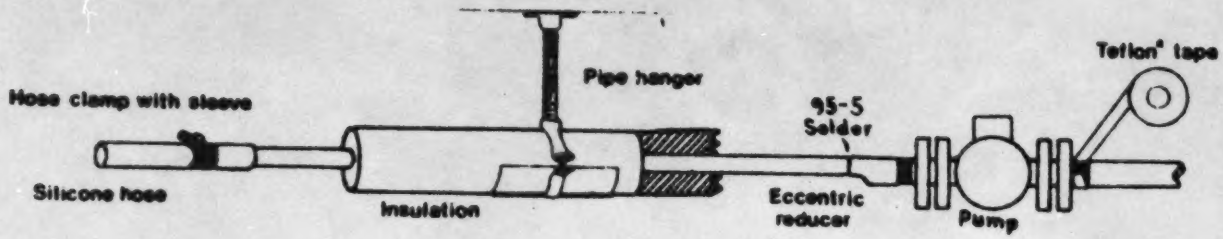


FIGURE 3 1 PIPE LENGTH AND VARIATIONS

PROCEDURE:

1. Prepare a board showing all common copper fittings in the 1/2 and 3/4 inch sizes, with a few black iron and galvanized fittings as well.

2. Demonstrate proper solder techniques, preferably letting the students make up joints with 95-5 solder. Stress the importance of proper temperature. Discuss silver/tin and silver/copper solders and their applications; fluxes and cleanings.

3. Demonstrate polyethylene and other useful plastic tubes and joints. Demonstrate proper fittings for silicone hoses.

4. Discuss types of pipe thread compounds and their applicability. Show samples of caulking sealants - urethane and silicone in particular - their usage and applications.

A SOLAR INSTALLATION SITE PLAN

OBJECTIVE: At the completion of this activity, students will be able to obtain a true north-south line to determine best solar orientation and determine the path of the sun across the sky at chosen site for mid-winter heating needs. This will help them to decide upon a plan to improve a site for a solar installation. Students may take this activity home to help make a solar plan for their own home site and make recommendations for improvement of their respective home sites.

TEACHER BACKGROUND:

The way in which a building is oriented is critical for the potential use of solar energy. In this activity students learn what is the best orientation for a new home or make an analysis of an existing structure such as their own home or school. Factors such as local climate and seasonal changes in the sun's path must be taken into account.

For both active and passive solar use a collector which should be oriented true south. Collectors 15^0 to the east or west of south perform nearly as well. With roofs of existing structures greater than 15^0 from south special mountings for solar collectors would have to be considered at an added expense.

Because the earth's magnetic field is not aligned parallel with the earth's north-south axis, there are some parts of the United States where the needle of a magnetic compass can point as much as 20 degrees east or west of true north. However, there are several ways to determine the true south in your area. You can consult a local surveyor, a plot map in your local tax office, or a recent isogonic chart of the United States published by the U.S. Coast and Geogetic Survey, U.S. Department of Commerce (Figure 1.7) and adjust your magnetic compass reading according to the meridian nearest to you. Don't use old charts, as there are annual variations in the readings. When using a magnetic compass, beware of standing near large metallic objects or power lines because they will affect the compass readings.

Also, you can easily determine true south yourself, right at the installation site. Place a stake in the ground and mark the location of the shadow on the top of the stake. Connect the end point of a morning shadow with the end point of an afternoon shadow by a straight line. A line drawn 90^0 to that line is a true north-south line. (Figure 1.8)

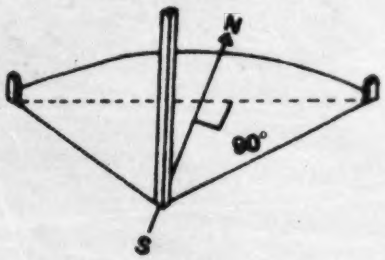
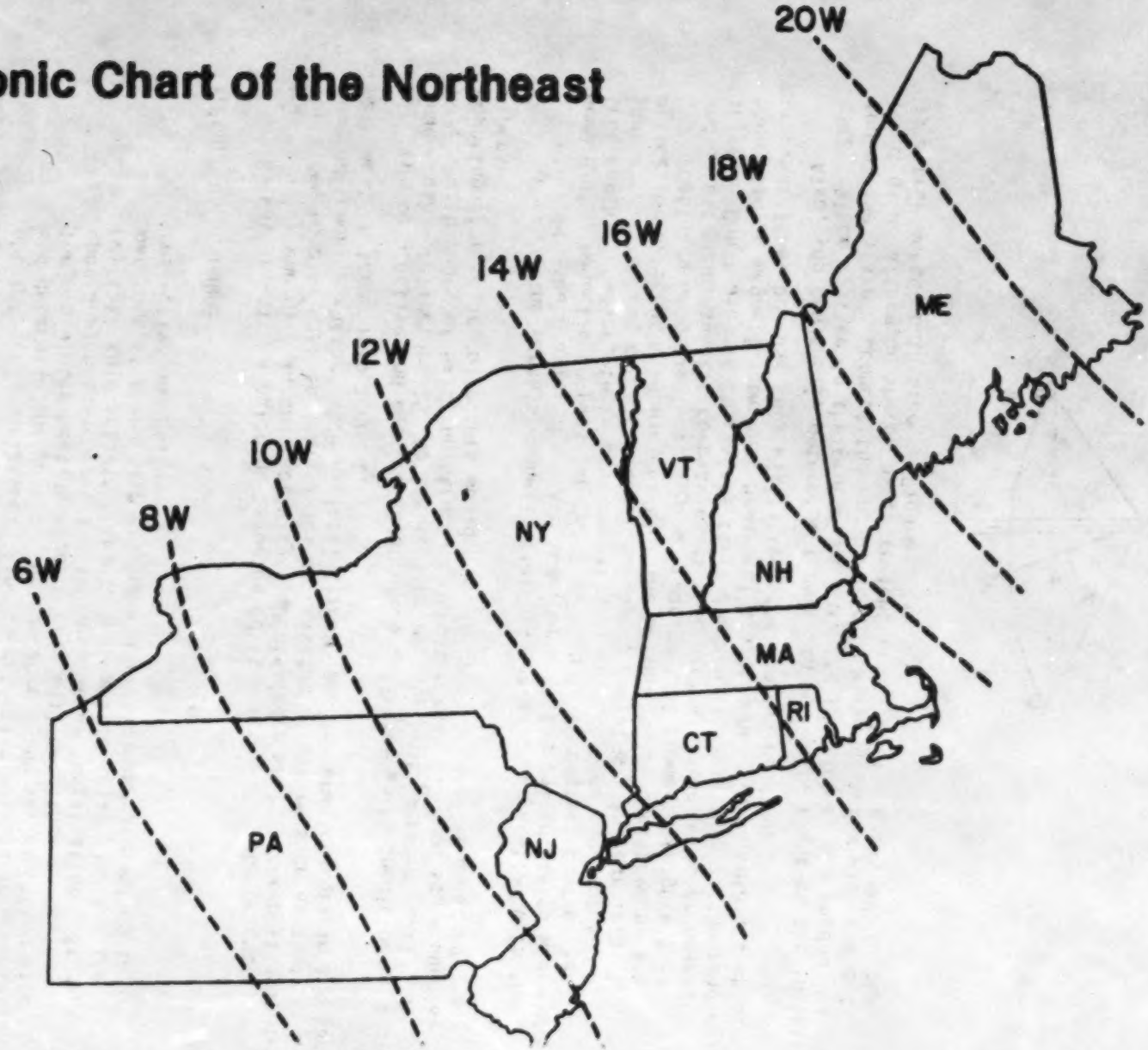


FIGURE 1.8 STAKE AND SHADOW METHOD

Isogonic Chart of the Northeast



H-110

52

53

There is an even faster way to determine your local north-south line. The shadow of a stake cast by the sun at solar noon will be on the true north-south line. Solar noon is exactly halfway between sunrise and sunset on any given day. Most local TV weather shows and newspapers give the exact times of sunrise and sunset each day.

Although performance will not be substantially affected, take local weather conditions into consideration when deciding on collector orientation. Although angling the collectors toward the east will start the system earlier in the morning, orientation slightly to the west can increase system performance because ambient temperatures are usually higher in the afternoon. As a result, collectors will lose less heat and operate more efficiently. If early morning fogs are common in your area, angle the collectors slightly toward the west.

COLLECTOR TILT

Collector tilt - the angle the surface of the collector makes with the horizon - is also an important factor in system performance. Ideally, collecto should be nearly as perpendicular to the sun's hottest rays as possible (Figure 1.9). For a solar DHW system, a tilt equal to the local north latitude is usually considered the optimum angle. Variations 10° either way will not

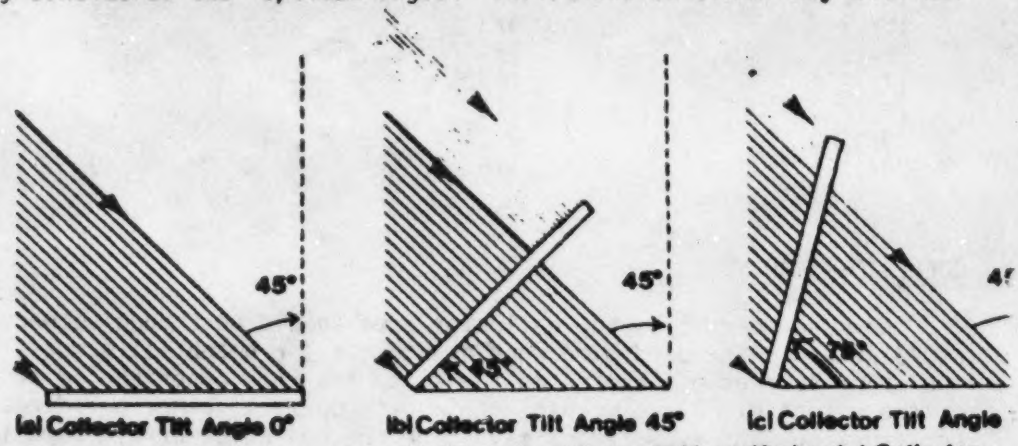


FIGURE 1.9: RADIATION ON HORIZONTAL, NORMAL AND NEARLY VERTICAL SURFACES

seriously affect the total annual performance of the system, all other things being equal, but a greater tilt will favor winter system operations when the sun is low in the sky (Figure 1.10). Also, in heavy snow areas a tilt of 50° will allow snow to slide off the collectors more readily. The following ch will help you determine the angle of the existing roof: (ANGLE/ROOF PITCH CONVERSION TABLE)

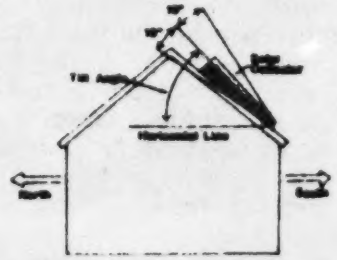


FIGURE 1.10: COLLECTOR TILT

TABLE 1.1 ANGLE/ROOF PITCH CONVERSION TABLE

SLOPE	PITCH	ROOF ANGLE (APPROX.)
2/12	1/12	9^{o}
3/12	1/8	14^{o}
4/12	1/6	18^{o}
5/12	5/24	22^{o}
6/12	1/4	26^{o}
7/12	7/24	30^{o}
8/12	1/3	33^{o}
9/12	3/8	37^{o}
10/12	5/12	39^{o}
11/12	11/24	42^{o}
12/12	1/2	45^{o}
13/12	13/24	48^{o}
14/12	7/12	50^{o}
15/12	5/8	52^{o}
16/12	2/3	54^{o}
17/12	17/24	55^{o}
18/12	3/4	57^{o}
19/12	19/24	59^{o}
20/12	5/6	60^{o}

COLLECTOR SHADING

No more than 5% of the collector area should be shaded between 9:00 a.m. and 3:00 p.m. Standard Time when greatest solar potential occurs. One of the major sources of shading is trees, so the home owner should be aware of the effect of future growth. Chimneys, dormers, other buildings, new construction, and even fences may shade the collector array, especially in the winter when sun angles are low and shadows are long. By knowing the altitude, (angle of sun above horizon) and azimuth (angle between true south and point on horizon below sun) of the sun throughtout the year, you can accurately determine if the homeowner is going to have shading problems.

THE SOLAR WINDOW

Imagine the sky as a transparent dome with its center at the solar collecto array of a house. The path of the sun during the year can be etched (projected) on the dome, as can the outline of surrounding houses and trees (Figure 1.11). The sun's path during the optimum hours between 9:00 a.m. and 3:00 p.m. Standard Time throughout the year scribes a "solar window" on the dome. Almost all of the useful sunlight that reaches the collector array must come through this window, except for the amount resulting from diffuse radiation. If any surround houses, trees, hills, etc. block part of this window, that intrusion will cast a shadow on the collector. The elevation of the solar window in the local will decrease with increasing latitude.

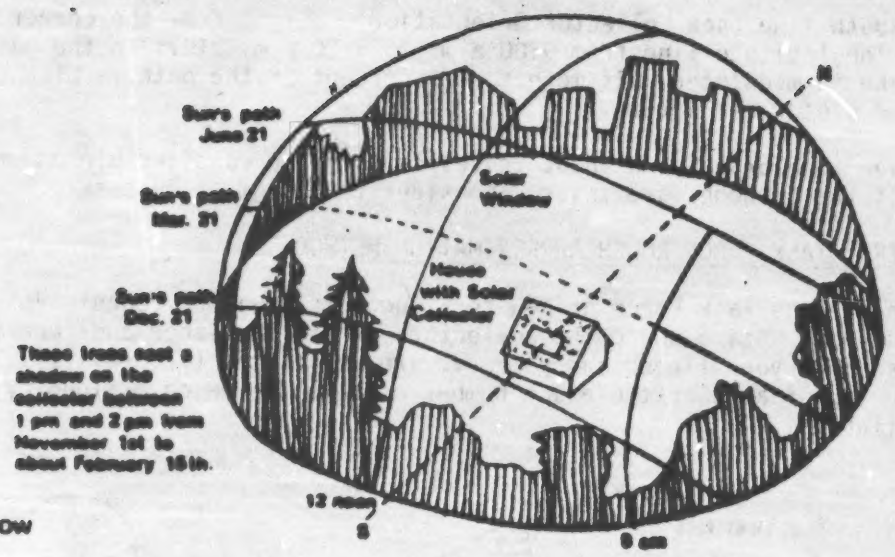

Sun's path June 21
Sun's path Mar. 21
Sun's path Dec. 21
Solar Window
House with Solar Collector
These trees cast a shadow on the collector between 1 pm and 2 pm from November 1st to about February 15th.
12 noon
S
9 am

FIGURE 1.11: THE SOLAR WINDOW

Mercator Projection

The sky dome with its "solar window" can be mapped using a Mercator projection in which the latitude and longitude lines are straight (Figure 1.12). Such a map is very useful for comparing the site surroundings with the "solar window", because

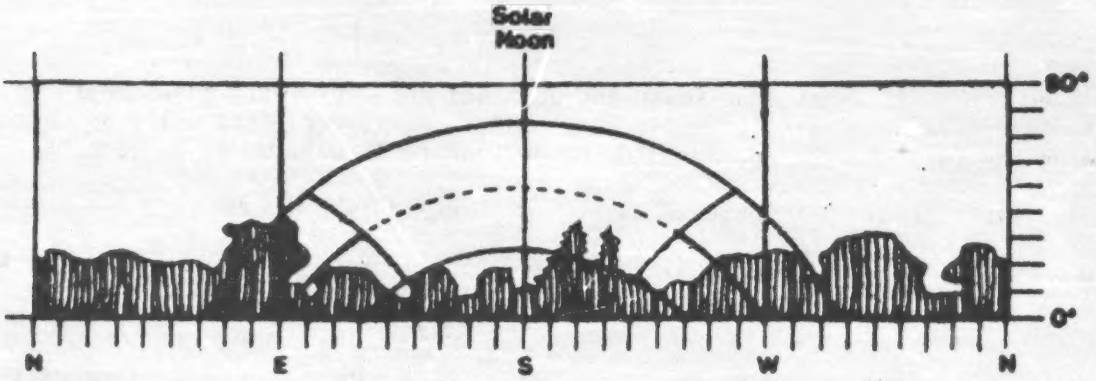


FIGURE 1.12: MERCATOR PROJECTION

both can be easily plotted on the map. Any elements surrounding the site that intrude into the "solar window" will cast shadows on the collector.

THE POPULAR SCIENCE SUN LOCATOR

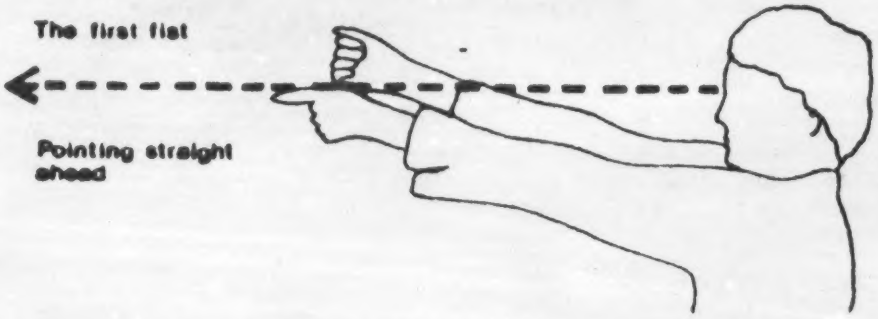
A simpler method was created for Popular Science Magazine*. Make a copy of the sun locator (Figure 1.13) and glue it to a cardboard backing. Trim along the line of the latitude nearest you. Place locator in a level position in the area where collectors are to be mounted. Align the compass along the correct magnetic declination line or per a recent isogonic chart (Figure 1.7) to obtain a true

north-south line (see Collector Orientation). Sight from the corner over the top of the latitude line from 9:00 a.m. to 3:00 p.m. This is the path the sun will take in midwinter. If more than 5 percent of the path is blocked, the site may need closer evaluation.

Even tree branches without leaves can block a considerable amount of winter sunlight if the branches are thick. Consider trimming, if necessary.

THE ENERGY TASK FORCE ROUGH APPROXIMATION METHOD

The Energy Task Force of New York suggests a way of roughly determining the solar window. Stand where the collectors are to be placed and face true south. Point so that your finger and your eye are horizontal (Figure 1.14). Place one fist on top of another the exact number of times to be determined by consulting the table (Table 1.2).



Sight over top of fists at true south and 30^0 east and west (with adjustments in fist height) to determine shading effects. Any object above your fists will cast a shadow on the collectors; and anything below your fists will be of no concern.

TABLE 1.2 THE ENERGY TASK FORCE SOLAR WINDOW APPROXIMATION METHOD

Latitude	12 o'clock position = 0^0 bearing	11 o'clock position = 30^0 bearing angle (EAST)	1 o'clock position = 30^0 bearing angle (WEST)
28°N	4½ fists (47° alt.)	3 fists (30° alt.)	same as 11 o'clock
32°N	3½ fists (34° alt.)	2½ fists (26° alt.)	same as 11 o'clock
36°N	3 fists (30° alt.)	2¼ fists (23° alt.)	same as 11 o'clock
40°N	2½ fists (27° alt.)	2 fists (20° alt.)	same as 11 o'clock
44°N	2¼ fists (23° alt.)	1½ fists (17° alt.)	same as 11 o'clock
48°N	2 fists (20° alt.)	1½ fists (14° alt.)	same as 11 o'clock

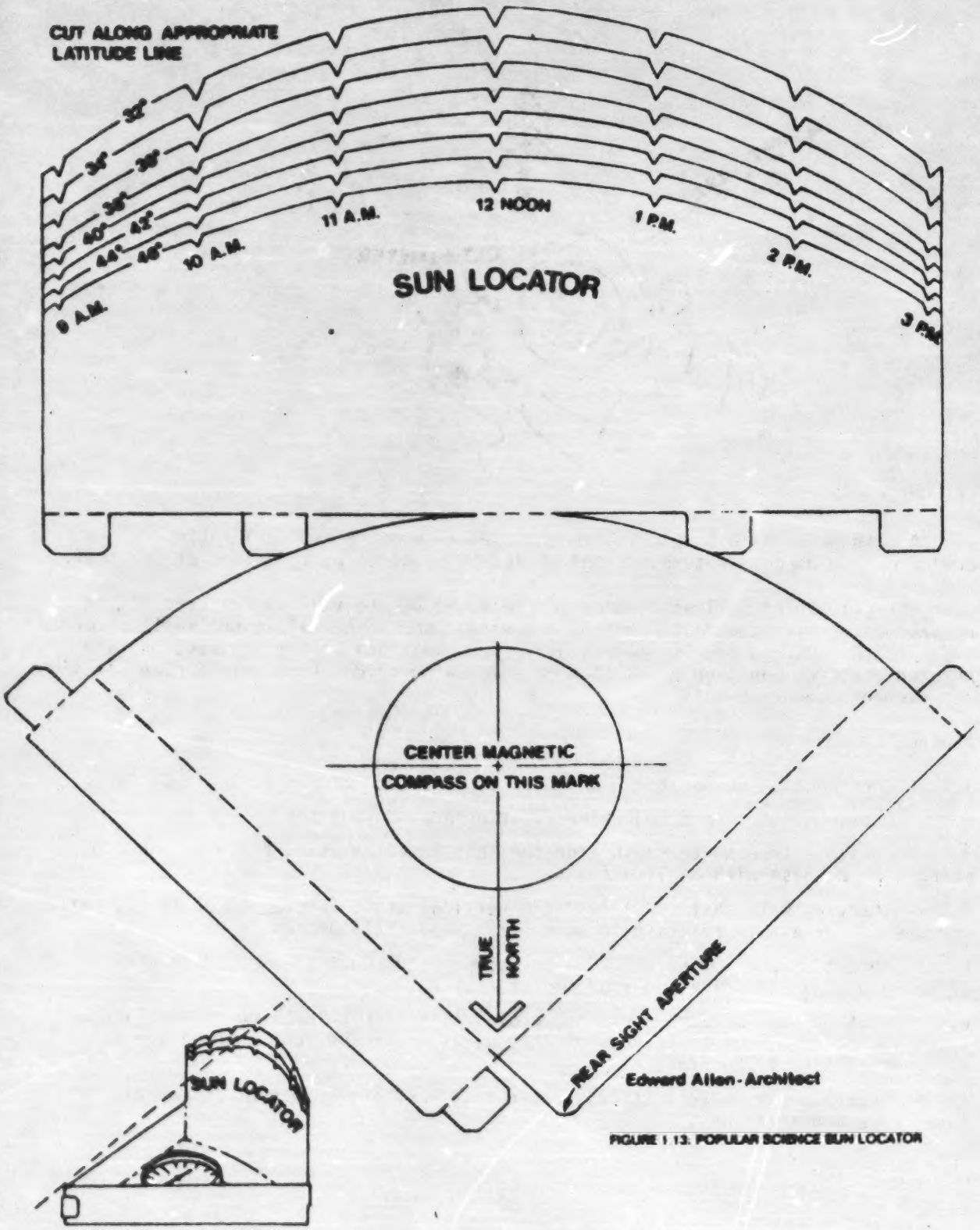
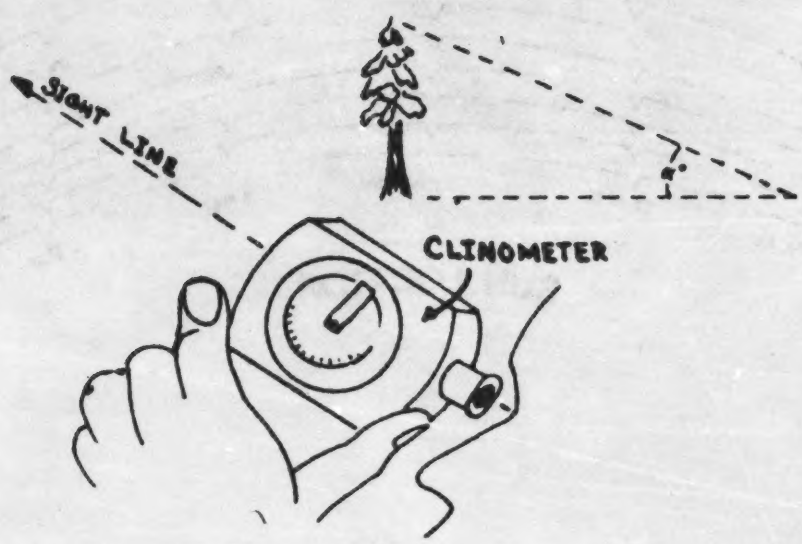


FIGURE 1 13. POPULAR SCIENCE SUN LOCATOR



CLINOMETER

A clinometer is a simple instrument used to measure vertical angles. This device may be used to determine roof angles by sighting up the slope of the roof.

The clinometer will also allow you to sight on the various features of the horizon especially those obstructing the winter sun. The altitude (vertical angle) and azimuth (compass bearing corrected for declination) of the obstructions and horizon features can then be plotted on a mercator grid. From this a plan for sight improvement can be formulated.

Procedure:

1. Construct a sun locator. Be sure to cut along the proper latitude line.

2. Choose a site for a solar-installation around your school.

3. Locate a true north-south line for this location using stake and shadow method, or compass with declination.

4. Starting with east (90^{o}) find the vertical angle (above 0^{o}) of trees, buildi and uneven terrain in relation to your site using a clinometer.

5. Repeat Step 4 for each 10^{o} on the compass to south (180^{o}) and finally to wes (270^{o}) and plot all points on your mercator grid.

6. Plot on your mercator grid the coordinates at each bearing. (Note whether trees are deciduous or coniferous as they will affect sunlight penetration at different times of the year).

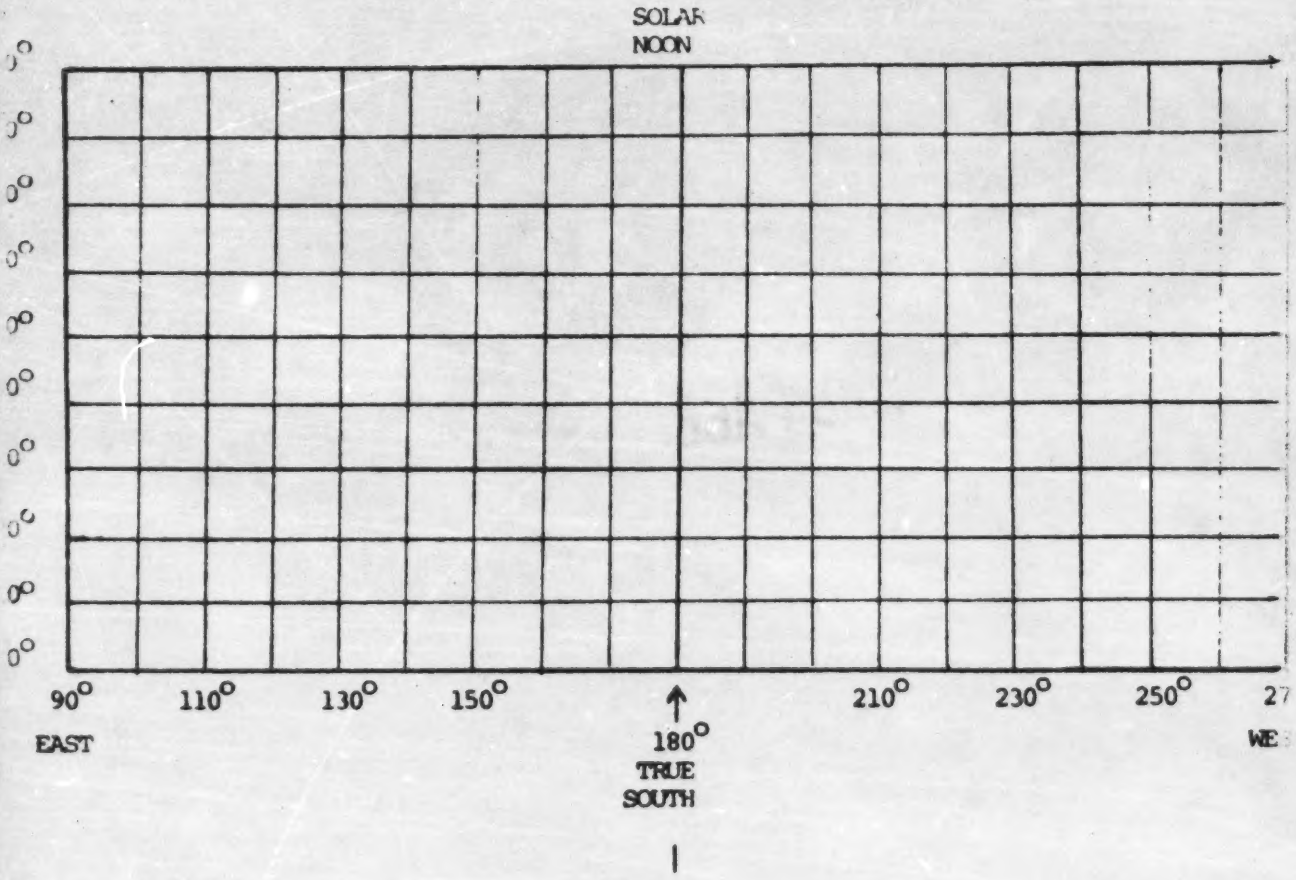
7. Determine if objects (trees, buildings, etc) are permanent or movable for later site modifications.

8. Using your "sun locator" determine the path of the midwinter sun across the sky for your site.

9. Plot this line on your mercator grid and determine what site features interfere with the sun's midwinter path.

10. Make a plan to modify the site for the best solar installation.

MERCATOR GRID



TALCOTT MOUNTAIN SCIENCE CENTER FOR STUDENT INVOLVEMENT, INC.

AVON CONNECTICUT
06001

PHONE: 677-8571

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November 4, 1981

Mr. Angelo I. Tedesco
Associate Commissioner
Division of Vocational Technical Schools
State of Connecticut
Department of Education
P. O. Box 2219
Hartford, CT 06115

Dear Mr. Tedesco:

This letter is to follow up our phone conversation of November 3 about using classrooms at the vocational schools for workshops. On September 28, I presented the Model Solar Energy Curriculum at the director's meeting in New Haven.

The purpose of the additional workshops is to reach teachers from different schools who could benefit from this curriculum. The curriculum itself was developed during the Model Solar Energy Training Programs I and II which were funded by Connecticut State Department of Education Division of Vocational Education.

The Talcott Mountain Science Center will be distributing copies of this curriculum to each teacher participating in one of the workshops. We need two regular classrooms at each school in which to hold these workshops. If possible, we would like one classroom to have easy access to an outside area. In addition, we would like to have a movie screen in one room. We will supply our own projector and over-head projector.

Because of the time of day, we would like to serve coffee for the participants. All that is needed from the school is a place to set up. We will supply everything needed including the coffee pot. I cannot think of anything else that we need except permission to use the following schools:

THE SCIENCE CENTER IS A NON-PROFIT EDUCATIONAL INSTITUTION FOUNDED IN 1967. FINANCIAL SUPPORT OF ITS OPERATION COMES ENTIRELY FROM FEES FOR SERVICES, TUITIONS, GRANTS AND GIFTS.

Date	Location
Tuesday, January 12, 1982	Bullard-Havens Regional Bridgeport
Tuesday, January 19, 1982	Southeastern Regional Groton
Wednesday, January 27, 1982	Henry Abbott Regional Danbury
Wednesday, February 3, 1982	H. C. Wilcox Regional Meriden
Wednesday, February 10, 1982	Windham Regional Willimantic
Wednesday, March 3, 1982	Oliver Wolcott Regional Torrington

If I can answer any other questions for you, please call. Again, thank you for your time.

Sincerely,

Robert S. Amrein

Robert S. Amrein
Assistant Director

RSA/gfd

CONNECTICUT STATE DEPARTMENT OF EDUCATION
Division of Vocational-Technical Schools
Hartford

November 6, 1981

TO:

FROM: Angelo J. Tedesco, Associate Commissioner
Division of Vocational-Technical Schools

SUBJECT: Attached Letter

Please comply with the attached request. Thank you in advance for your cooperation with this request.

These workshops will take place after the official close of the school day.

AJT:fl

cc: Robert Amrein, Talcott Mountain Science Center

Att.

TALCOTT MOUNTAIN SCIENCE CENTER FOR STUDENT INVOLVEMENT, INC.

AVON CONNECTICUT 06001

PHONE: 677-8571

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Robert S. Amrein

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Assistant Director

RSA/gfd

TALCOTT MOUNTAIN SCIENCE CENTER FOR STUDENT INVOLVEMENT, INC.

AVON CONNECTICUT
06001

PHONE: 677-8571

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Dear Principal:

Last year you cooperated with us in the dissemination of our MODEL SOLAR TRAINING PROGRAM. The course was very successful in all aspects. The Bureau of Vocational Program Planning and Development, Connecticut State Department of Education, has funded the dissemination workshop to help in the education of teachers in the area of Solar Energy.

We would appreciate your help in distributing the enclosed announcement to members of your staff who would find this program valuable.

Thank you,

Robert S. Amrein
Assistant Director

RSA/gfd

Enc.

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ATTENTION: ALL TEACHERS AND ADMINISTRATORS OF VOCATIONAL AND TECHNICAL EDUCATION (SHOP AND SCIENCE TEACHERS)

SUBJECT: A MODEL SOLAR ENERGY DISSEMINATION WORKSHOP PROGRAM FOR VOCATIONAL EDUCATION TEACHERS

Talcott Mountain Science Center is pleased to announce that we are conducting a series of workshops under contract with the Connecticut State Department of Education, Division of Vocational Education, Bureau of Vocational Program Planning and Development. This academic year workshop offerings will be designed for teachers and cover three areas: an overview of the energy problem itself, hands on experiences with activities developed during the Model Solar Energy Training Programs, and exposure to additional curriculum materials available to them.

There is NO CHARGE for this exciting course. Since interest in this program is high (we had five applications for every place in the program last year) and the time is short, we encourage you to complete and mail the registration form below as soon as possible. The workshops will be held from 3:30 to 6 p.m. on the dates and at the locations shown on the registration.

MODEL SOLAR ENERGY DISSEMINATION WORKSHOP PROGRAM FOR VOCATIONAL EDUCATION TEACHERS

Name_____ School_____

Home Address_____
street city state zip

Phone Number_____
home business

Please check one

Tuesday, January 12, 1982	Bullard-Havens Regional, Bridgeport	_____
Tuesday, January 19, 1982	Southeastern Regional, Groton	_____
Wednesday, January 27, 1982	Henry Abbott Regional, Danbury	_____
Wednesday, February 3, 1982	H. C. Wilcox Regional, Meriden	_____
Wednesday, February 10, 1982	Windham Regional, Willimantic	_____
Wednesday, March 3, 1982	Oliver Wolcott Regional, Torrington	_____

TALCOTT MOUNTAIN SCIENCE CENTER, MONTEVIDEO ROAD, AVON, CONNECTICUT 06001

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[illegible] PANOSCIO Ph D

DONALD P LA SALLE Ph D Director
[illegible] Associate Director
[illegible] Senior Assistant Director
ROBERT S AMREIN Assistant Director

Dear

This will confirm your reservation for the Solar Vo-Ed Workshop at
to be held , from 3:30 - 6 PM.

If, for some reason, you are unable to attend, please call Robert Amrein at Talcott Mountain Science Center, 677-8571.

Sincerely,

Robert S. Amrein
Assistant Director

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